# TUMORS OF THE ACOUSTIC NERVE, THEIR SYMPTOMS AND SURGICAL TREATMENT.

## WITH THE REPORT OF A CASE OF COMPLETE RECOVERY AFTER OPERATION BY DR. HARVEY CUSHING.

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Tumors of the cerebellum may be divided into two classes, those involving the hemispheres and the central portion, and those lying upon the base of the brain in the cerebellar pontine angle. While the diagnosis of a tumor within a mass of the cerebellum is not, as a rule, difficult, it is as yet almost impossible to locate exactly the position of such a tumor. Tumors of the acoustic nerve, on the other hand, which occur with about equal frequency with tumors within the cerebellum, are much more readily diagnosticated.

In the early history of brain surgery attempts at removal of tumors in the cerebellum so frequently failed that surgeons became reluctant to undertake this operation. Within the last five years, however, it has been necessary to change this view, and, with the improvement of technique, there have been recorded a large number of successful cases of surgical interference in cerebellar tumors, and more particularly in tumors affecting the acoustic nerve. It seems worth while, therefore, at the present time to present a summary of our knowledge of this subject, to discuss the symptoms and diagnosis of tumors, especially of the acoustic nerve; to collect and analyze cases of operation upon tumors of the cerebellum up to the end of 1909, to discuss their pathology as bearing upon the prognosis of operation, and to describe the technique which has been productive of favorable results. I venture to do this because of my experience in thirteen cases of tumors of the cerebellum, in eleven of which an operation has been undertaken, and because of the fact that I can present a case of perfect recovery ten months after removal of a tumor of the acoustic nerve.

The general symptoms of brain tumor, headache, vertigo, vomiting, and choked disk, which usually appear early in the course of all cerebellar tumors, need no special comment. It is the localizing symptoms which make tumors of the cerebellum, and especially tumors of the acoustic nerve, of particular interest.

Symptoms of Tumors of the Acoustic Nerve. The symptoms which indicate the location of a tumor in the cerebellar pontine angle upon the acoustic nerve may be divided into three classes: (1) Those referable to the cranial nerves; (2) those referable to the involvement of the cerebellar peduncles; and (3) those referable to compression of the tracts passing through the pons.

1. *Symptoms Referable to the Cranial Nerves:*

(*a*) Slight anesthesia of the face on the side of the tumor, first shown by corneal anesthesia and an absence of the corneal reflex.

(*b*) Weakness of the external rectus muscle of the eye on the side of the tumor, due to a pressure on the sixth nerve. This may be first noticed by the occurrence of nystagmus on turning the eyes toward the side of the tumor, and later a decided internal strabismus may occur. The eye looks away from the tumor.

(*c*) A weakness of the muscles of the face on the side of the tumor, first noticeable in a slight disturbance of the act of winking and a slight lack of expression, which is later followed by an actual weakness of all the muscles supplied by the seventh nerve. Pressure on this nerve is rarely, if ever, sufficient, however, to cause a reaction of degeneration in these muscles.

(*d*) Tinnitus in the ear on the side of the tumor, soon followed by some deafness in the ear, which may be slight and only detected by tests with the Galton whistle, high notes or low notes, or both, being lost. This deafness may be as marked for bone conduction as for ear conduction.

(*e*) Vertigo, felt by the patient as a sensation of falling toward one side, or as a sensation of rotary movement of the body, both of which symptoms must be ascribed to irritation of the labyrinthine division of the auditory nerve.[1]

(*f*) Difficulty of swallowing and hoarseness of the voice, owing pressure on the ninth nerve.

(*g*) Sudden attacks, which may be called vagal attacks, referable to irritation of the tenth nerve, consisting of rapid pulse, sensations of flushing of the body or of the head, sudden faintness without an actual loss of consciousness, attended by more or less vertigo.

(*h*) Paralysis of the tongue, shown by thickness of speech or difficulty of articulation, and by protrusion of the tongue toward the side of the tumor.

2. *Symptoms Referable to the Involvement of the Cerebellar Peduncles.* The second set of symptoms is referable to the compression of the cerebellar hemisphere and its peduncles. The portion of the cerebellum that will necessarily be involved is the flocculus, which projects over the middle peduncle of the cerebellum as it comes from the pons. As we have no means of distinguishing between the functions of different portions of the cerebellum,[2] it is uncertain whether the symptoms of a cerebellar nature are due to destruction

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[1] I cannot confirm the statement of Stewart and Holmes (Brain, 1904, p. 525), that in cerebellar tumors the sense of displacement of objects in front of the patient is from the side of the lesion to the opposite side. They also state that when a tumor is within the cerebellum the subjective rotation of self is from the side of the lesion toward the healthy side, but when the tumor is outside the cerebellum the subjective rotation is from the healthy side toward the side of the lesion. Oppenheim has also failed to confirm this assertion.

[2] See Horsley and MacNulty, Brain, January, 1910.

of this flocculus or of the two peduncles entering the cerebellum just under the site of the tumor. These symptoms are:

(*a*) A staggering gait and feeling of uncertainty of the position of the body in space when supported upon the legs, which causes swaying when the eyes are closed and staggering when the eyes are open, attended by a disagreeable sense of vertigo, which leads the patient to seek support whenever in a standing posture. The direction of the staggering is, in the majority of instances, away from the tumor, although cases have been put on record in which the patient staggered toward the side of the tumor. The direction of the staggering is not to be taken in itself as a very important symptom, but the fact that the patient staggers *uniformly toward one side* is an important symptom of an affection of the peduncles of the cerebellum as they enter the organ, and therefore the existence of staggering in a definite direction, combined with evidences of the implication of the cranial nerves upon one side, is a definite local sign of a tumor in the cerebellar pontine angle.

(*b*) Another symptom of cerebellar origin is an imperfect muscular tone in the muscles of the arm and leg on the side of the tumor. It is uniformly admitted that the cerebellum has a direct tonic influence upon the muscles, and that this influence is homolateral. This lack of tone is attended by an awkwardness of movement not due to any actual weakness, but to an imperfect coördination of the motions performed. Thus, rapid movements made by both hands or fingers together often prove that the hand on the side of the lesion is moved less freely, rapidly, and skilfully; and other tests may show a true ataxia. There may be also an ataxia of the leg, so that to stand on one foot is impossible. Such an ataxia in the leg may lead to staggering toward the side of the tumor. This symptom has been named diadokokinesis. The maintenance of a proper tone in the muscles appears to have some relation to the response of those muscles to irritation, and it is probably on this account that lesions of the cerebellar peduncles or of the cerebellum are usually attended by a loss of knee-jerk and of the deep reflexes on the side of the lesion; yet this symptom of a loss of reflex on the side of the tumor is not always found in these cases of pontine angular growth. It has been observed, however, in too many cases to allow us to overlook it.

(*c*) Another symptom of importance due to cerebellar lesion is the abnormal position of the head. Whether this is due to a loss of tone in the muscles of the neck which support the head, or whether it is due to the weight of the tumor, producing instinctive drawing of the head downward toward the side of the tumor, or forward or backward, according to the position of the tumor in relation to the axis of the body, may be left uncertain. A reference to Fig. 1, which shows the position of such a tumor inserted in the diagram of Fraser, will indicate that a tumor at this location is very near to the centre of gravity of the head, and it can be readily imagined that a tumor growing backward might so disturb the equilibrium of the head as to lead to an abnormal position, which might be backward, but would naturally be more toward the side of the tumor than away from it.

3. *Symptoms Referable to Compression of the Tracts Passing Through the Pons.* A third set of symptoms is to be traced to a compression of the motor tracts and sensory tracts passing through the pons and medulla on their way to and from the limbs of the opposite side. Compression of the pons is very much less likely to cause disturbance in the transmission of sensation than in the transmission of motor impulses, and therefore weakness of a hemiplegic type in the arm and the leg in the side opposite to the tumor is more commonly observed than is anesthesia in the corresponding parts. This weakness is usually attended by an exaggeration of the reflex, by an increase in the knee-jerk, ankle clonus, and Babinski reflex, and such exaggeration is doubly evident because of the loss of the knee-jerk upon the side corresponding to the tumor. This weakness of one leg may intensify the difficulty of walking and may influence very markedly the gait. A patient with a weak leg has something of a tendency to stagger toward the leg that is weak, to use it less freely, and to bend downward toward that side. It has already been remarked that many of these patients stagger away from the tumor, and it is not at all impossible that this direction of the staggering is due to the imperfect use of the leg on the side opposite to the tumor. The actual weakness present in the arm or leg may be easily detected by dynamometer tests, and in many cases has amounted to such a marked hemiplegia that any use of the arm or of the leg was impossible. While anesthesia and analgesia in the limbs of the side opposite to the tumor is much less commonly observed than is paralysis, many patients complain of feelings of numbness, tingling, gooseflesh, or burning in these limbs; and such paresthesias may be followed by an actual disturbance of sensation. In the advanced stages of these cases, in which the patients have died of the tumor, a hemiplegia has developed toward the close of life, not, however, involving the face, and it is in these extreme cases that anesthesia has been observed in the paralyzed limbs.

The diagnosis, therefore, of these tumors is easily made from these three sets of symptoms: (1) Of the cranial nerves; (2) of the cerebellum; and (3) of compression of the sensory and motor tracts.

CASES OF ACOUSTIC TUMORS.: In the following case, which was first recorded in 1893,[3] the diagnosis was quite clear:

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[3] AMER. JOUR. MED. SCI., April, 1893.

CASE I.—*Tumor of the acoustic nerve; operation; tumor not found; autopsy.* M., aged thirty years, was under my observation from January, 1890, until December, 1891. When first seen he was suffering from severe frontal and occipital headache, from vertigo, which was much increased by moving the head suddenly or while lying down; from tinnitus aurium, from numbness of the left side of the face and in the mouth, and from a very continuous feeling of drowsiness and dulness. These symptoms had developed gradually during the preceding three years, and within a year he had also noticed double vision and a gradually increasing blindness. His friends said that his speech had become "slow and thick."

He was referred to me by Dr. Weeks, from the Eye Department at the Vanderbilt Clinic, where an examination had shown great prominence of the eyeballs, the left one deviating outward; dilated pupils; marked nystagmus on lateral movements of the eyes; well-marked choked disks; and diminution of all visual fields.

My examination showed that there was some slowness of speech, which was accounted for by his mental dulness, there being no evidence either of aphasia or of paralysis of the tongue. There was no disturbance of sensation, of motion, or of reflex action, and there was no ataxia in the gait. The existence of headache, vertigo, tinnitus, nystagmus, diplopia, and choked disks established the diagnosis of a cerebral tumor, but no conclusion could at first be reached with regard to its location. During the year 1890, however, other symptoms developed which aided in the localization. The patient gradually became deaf in the left ear; he began to stagger in walking with a tendency to fall forward and toward the right, and a very marked tendency to turn toward the right in walking along a straight line. In addition, there developed a weakness in the right hand and exaggeration of the knee-jerk on the right side, with slight clonus in the right foot. There was no ataxia or disturbance of sensation in the limbs. The staggering was that of a drunken man, without falling, but with every appearance that the balance was quite uncertain, and the tendency to turn and fall to the right was quite constant and noticed at every examination. The pain and numbness in the left half of the face continued occasionally during the year, but there was never at any time any anesthesia. The tinnitus in the left ear disappeared gradually and the deafness in the ear increased. The headache, which at first had been frontal, was later referred more and more constantly to the left occipital region, and in speaking of it he habitually put his hand back of his ear.

A thorough course of specific treatment was carried out during the years 1890 and 1891 without any results. Toward the close of 1891 his condition had become one of complete helplessness and total blindness. The staggering was so exaggerated that he could not walk about without the help of two persons, and he was finally induced to enter Roosevelt Hospital in December, 1891, for an operation. This operation was done by Dr. McBurney on December 3, 1891. The left half of the occipital bone was exposed by a tongue-shaped flap. The bone was removed by chisel and mallet, an opening about an inch and a half in diameter and triangular in shape being made through the occipital bone. The dura bulged strongly through this opening, indicating great increase of intracranial pressure. When the dura was divided the cerebellar tissue protruded, and it was necessary, in order to go on with the operation, to cut off quite an amount of cerebellar substance in order to palpate the parts below. The finger was introduced along the various accessible surfaces of the cerebellum, but nowhere was it possible to reach the tumor. Hemorrhage was only moderate, and easily controlled by pressure. The flaps of the dura were united, the overlying soft parts replaced and fastened with catgut sutures, the skin wound being sewed with silk.

Convalescence was perfectly satisfactory from the immediate operation, and six days after the operation, normal temperature having been maintained throughout, primary union was found throughout the whole extent of the wound, and all sutures were removed. The patient, therefore, had recovered from the operation, but the operation had been of no service. There was every reason to believe that he would have remained in the condition in which he was before the operation, but unfortunately, on the seventh day he fell out of bed, and soon after died from a hemorrhage which had occurred, as a result of this fall, under the skin flap.

At the autopsy a gliosarcoma, quite distinctly limited, from the cerebellar and adjacent tissue, was found lying on the base and compressing the left hemisphere of the cerebellum on its anterior inferior surface, pressing upon the left half of the pons and compressing the seventh and eighth nerves.

This I believe to have been the first attempt of the surgeon to remove a tumor from this cerebellar pontine angle, and the lesson to be drawn from the operation was that by a unilateral opening through the occipital bone it was almost impossible to reach the tumor. Reference to Fig. 1 will show that a great portion of the cerebellum lies between the bone at this location and the tumor. In spite of this difficulty, another attempt was made by Dr. McBurney, on March 12, 1893, to remove a similar tumor, and with success. The history of this case is as follows:[4]

CASE II.—*Tumor of the acoustic nerve; operation; tumor removed; death.* W. W., aged ten years, began to suffer, in October, 1892, from frontal headaches, worse at night; then from an occasional vertigo and attacks of intense headache, associated with vomiting, and occurring every third or fourth night. During December he became rather dull mentally and very irritable, and then the symptom of staggering was first noticed. During January, 1893, he was examined by Dr. Kipp, of Newark, who found a well-marked condition of optic neuritis, and then for the first time he noticed some dimness of vision. At that time he was still able to read large print without much difficulty, but by February 1 he had become almost totally blind. During February the headaches, usually nocturnal, increased in severity, were always associated

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[4] Reported in Brain Surgery, Case XXIV, p. 247, Wm. Wood & Co., 1893.

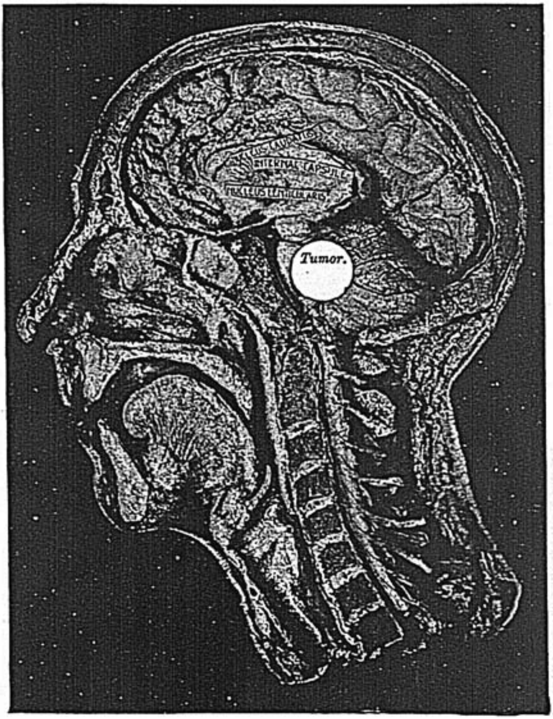

Fig. 1.—Fraser's photograph of a sagittal section of the head, showing the situation of the acoustic tumor in Cases II and VI.

with vertigo and vomiting, and he began to have ringing in the left ear and deafness in the right ear. His gait was noticed to be very unsteady, his eyes were prominent and in constant oscillation, and his mental dulness was intense.

He was referred to me by Dr. William Pierson, of Orange, N. J., on March 12, 1893, with the preceding history.

Examination showed a fairly nourished but pale little boy, with a large head, prominent forehead, protruding eyes that were blind and in constant lateral oscillation. At rest, there was a manifest tendency of the right eye to turn inward, but he could look in either direction without apparent paralysis of the ocular muscles. All ocular movements were attended by marked nystagmus. Very extensive optic neuritis was found in both eyes, and he was blind. Smell was lost in the left nostril. There was no apparent paralysis or anesthesia in any part of the body or face, but a slight facial paresis on the right side was noticeable, and he was unable to whistle on account of inability to close the right half of the mouth. His hearing was decidedly defective in the right ear. His reflexes were diminished in both knees. His gait was distinctly a staggering gait, with a very marked tendency to stagger toward the left side. In groping his way forward he would tend to turn toward the left side. He described his headaches as being agonizing, and referred them entirely to the frontal region. The skull was tender to percussion over the vertex. The headache was very much increased by a recumbent posture, so that for many nights he had sat up all night.

The diagnosis of a tumor in the cerebellar pontine angle was reached by the symptoms of cerebellar gait, with a tendency to stagger to the left side, by the deafness in the right ear, and slight weakness of the right side of the face and of the right external rectus muscle, and an operation was therefore recommended.

On March 15, 1893, Dr. McBurney exposed the occipital bone on the right side, chiselling it away and enlarging the opening so far as possible in all directions by a rongeur. On dividing the dura, which bulged tremendously, a cyst, containing a dram of yellowish-green fluid, was exposed and evacuated. When the cerebellum was crowded over toward the median line beneath this cyst wall, a tumor was felt. The portion of the cerebellum which had bulged into the wound was then sliced off in order to give access to this tumor. It was gradually enucleated by the aid of a finger and a spoon. It contained one or two small cysts, which ruptured in the process of its extraction. It was gradually removed, being shelled out from the cavity in the cerebellum; it had no distinct capsule. Clean cerebellar tissue was left around the previous site of the tumor. Hemorrhage was arrested by compression and by packing the wound, and a drain was left in the wound, and the dura and scalp were closed.

The boy recovered from the shock of the operation, but gradually grew weaker, and after about two weeks died in the hospital. This was, I believe, the first successful case of removal of a tumor from this locality.

The record of operations upon the cerebellum up to the close of 1893[5] showed that 15 cases had been operated upon, and that in one only had successful removal of the tumor, with recovery of the patient, been recorded. Discouraged by this record, for a number of years I refused to recommend operation in cases of cerebellar tumor.

The next case I will not give fully. It was one in which the autopsy showed a cyst of the cerebellar pontine angle. The most prominent symptom was a mental deterioration and progressive dementia. No diagnosis of the location was made.

Case III.—*Cyst of the cerebellar pontine angle; no diagnosis; autopsy.* Female, aged fifty-three years, began to suffer in October, 1895, rather suddenly, from a numbness of the entire left side of the body and marked unsteadiness in gait. Soon after she noticed that the leg felt heavy in walking, so that she thought she dragged it, but as a matter of fact she used all the muscles freely. During this time the motions of her left hand became awkward, and it was found that she frequently let things fall out of her hand. During the winter of 1896 these symptoms continued and increased, and it was noticed that she was becoming progressively more and more dull mentally, as shown by her lack of interest in things about her when sitting idle, when formerly she had been an active woman, and by her becoming unable to play whist.

When seen on January 24, 1896, in consultation with Dr. Adler, her optic disks were found to be normal; fields of vision normal; ocular movements normal, but attended by a nystagmus on turning the eyes to either side. There was a flatness of the left side of the face, the left eye not winking normally with the other, but it was possible to close the eye, and voluntary movements of the lips and cheek were perfect. There was no paralysis of the left arm or leg, motions of resistance in all directions and in all muscles being perfect and reflexes normal, but there was a marked ataxia of both left arm and hand and of the left leg. The hand was held in an awkward position. Her sense of position of the hand in space and of the position of the fingers was imperfect, but sensations of touch, temperature, and pain were normal and equal on both sides. She had complained of a good deal of pain over the left ear and behind the left ear, but she had no deafness, no vertigo, no vomiting. The case, therefore, at this time seemed to be quite obscure, and no diagnosis was possible. She was subject to uterine hemorrhages, and was exceedingly anemic, and for this condition she was treated during the year of 1896, but during that year she became progressively worse, the feebleness of the left side and awkwardness steadily increased, so that by October, 1896, she was unable to walk without help, and in November, 1896, she was confined to her bed. The ataxia of the arm had also increased during this time, so that the arm was practically useless for finger movements; she could no longer feed herself or adjust her hair. The facial paralysis on the left side had also increased.

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[5] Brain Surgery, p. 249.

When seen again, on January 17, 1897, in consultation with Dr. Polk and Dr. Knapp, the facial paralysis was quite complete, of the peripheral type. The power in the left arm and left leg was almost normal, but the ataxia in both limbs was very pronounced. Motions of the eyes produced nystagmus, and it seemed impossible for her to turn her eyes conjugately toward the left, but there was no strabismus. During the year of 1896 her mind had become progressively impaired, so that in January, 1897, she was almost in a condition of stupor. It was with great difficulty that she answered any question. She did not seem to pay attention to questions or to requests until they had been repeated over and over, but then, when they finally appeared to reach her consciousness, she would answer or act appropriately. She could not balance herself in a sitting posture in bed; she had been totally incapable of standing on her feet for a month of more, and if held up in the bed her head fell backward, and a great deal of pressure backward was made of the entire body. This tendency to fall backward had been noticed by others for several weeks. For the last two months there had been an absolute lack of control of the sphincters, and she had paid no attention to the wants of nature. This was ascribed to the obscure mental condition. The optic disks, examined by Dr. Herman Knapp, were found to be normal. There was apparently no deafness, no anesthesia, no blindness. She did not suffer from headache, vertigo, or vomiting; she was fairly nourished.

During the month of January she lay in the same condition of stuporous indifference to her surroundings, never roused up of her own accord, or spoke, though if sharply questioned, after a considerable length of time would reply accurately. In addition to the facial paralysis of the left side, there had developed by February 1 an anesthesia of the left cornea and slight tactile anesthesia of the left side of the face. The tendon reflexes of the left side had become much exaggerated, the ataxia remained, but no paralysis had appeared. During the month of February she grew progressively more feeble, an infection of the bladder occurred, and on March 2 she died.

The autopsy showed the existence of a cystic tumor lying on the left side of the pons, at the position of its junction with the medulla and the cerebellum, all of which organs were deeply indented by the tumor The tumor measured 5,5 cm, in an anteroposterior direction, 4.5 cm. laterally, and 2 cm. vertically. It was a cyst filled with fluid of a whitish color, in the walls of which irregular thickenings of fibrous nature were seen. The tumor was not adherent anywhere to the brain, but it was adherent to the dura just behind the ridge of the petrous portion of the temporal bone. The seventh and eighth nerves ran in the wall of the tumor, and were torn off from the brain in removing it. The sixth nerve had been compressed by the anterior edge of the tumor. The pressure of the tumor had indented the pons deeply upon its side; but had not compressed the pyramidal tracts of the medulla. The pressure on the medulla had been exerted upon the olivary body and restiform body, which were compressed backward. The cerebellum was deeply indented in its middle peduncle, so that when the tumor was removed a deep indentation in the middle peduncle of the cerebellum was visible. The ventricles of the brain contained a considerable amount of clear serum, and were distended more in the posterior horns than in the anterior; but this distention was not very marked. The brain did not appear to be very much compressed, the convolutions were not markedly softened, and the dura was not very tense. There were no changes in the pia and no hemorrhages within or upon the brain. The cerebral hemispheres were normal.

In reviewing the history of this case, which was throughout its clinical course most obscure, and in which the only general diagnosis was one of brain tumor without any definite localization, it is evident that the pressure upon the seventh nerve was the first symptom, together with the ataxia of the limbs on the side of the tumor, with a tendency to fall in walking, to stagger, and to fall backward. As the tumor advanced, the left sixth and fifth nerves were involved, but it is rather surprising, in consideration of the fact that the tumor involved the acoustic nerve, that there were no symptoms of deafness or of vertigo, and in view of the size of the tumor, it is quite surprising that there were no symptoms of optic neuritis. The mental condition was really the most noticeable of all the symptoms present.

While mental symptoms occur in between 50 and 60 per cent. of all cases of brain tumor, as shown by the careful analysis made by Schuster,[6] yet it has been noticed that in tumors of the cerebellum such mental symptoms are only present in about 25 per cent. of the cases. As a rule, they consist of a progressive stuporous condition, with dementia; rarely hallucinations occur; usually there is a condition of progressive inability to use the mind. I have elsewhere pointed out the frequency of this symptom in connection with tumors of the corpus callosum and of the frontal lobes.[7] But the case here put on record is the only case of tumor of the cerebellum which I have seen in which such mental symptoms appeared. Ballance[8] states that the mental state is normal, or only affected late, as a consecutive phenomenon. Glasow,[9] in recording a case of cerebellar tumor, has noticed such mental symptoms, but the rarity with which these symptoms are recorded in the large number of cases of cerebellar tumor which I have been able to gather convinces me that the percentage given by Schuster is excessive, and than in not more than 10 per cent. of cerebellar tumors are mental symptoms observed in the early stages. It is, of course, true that in the later stage of the disease, when the ventricles are distended by fluid and the general intracranial pressure is much increased, under which circumstances the patients are likely to be blind, a demented state may develop, but as an early symptom of tumor of the cerebellum, I believe mental disturbances are most unusual.

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[6] Psychische Störungen bei Gehirn Tumoren, Stuttgart, 1902.

[7] Amer. Jour. Med. Sci., 1895, "Tumor of the Corpus Callosum, with Autopsy," by Francis and Starr.

In 1903 the following case was seen at the clinic, and was sent to the Presbyterian Hospital for the purpose of an attempt at removal of the tumor.[10]

CASE IV.—*Tumor of the acoustic nerve; sudden death.* F. K., aged seventeen years, when seen at the clinic, had all the symptoms of brain tumor, which had lasted about a year, developing gradually. She had severe headaches, worse in the morning on awakening; attacks of vomiting; intense vertigo, and double choked disk, which was gradually impairing her eyesight. She had also a typical cerebellar ataxia, staggered in walking, found it difficult to maintain her balance, and had a marked tendency to stagger toward the right side.

Examination showed a slight weakness of the left external rectus muscle, flattening of the left side of the face without any actual paresis, and marked deafness in the left ear. While there was no paresis of the limbs of the right side, the reflexes on that side were markedly exaggerated. She had had many attacks of sudden faintness with vertigo and a sensation of alarm, which were interpreted as vagal attacks. She had become somewhat dull mentally, but was intelligent enough to give satisfactory answers to all questions, and presented no other symptoms than those here described.

It seemed probable from these symptoms that the tumor lay upon the base of the brain, involving the cerebellum, the sixth, seventh, and eighth cranial nerves, and with this diagnosis in view, Dr. McCosh agreed to operate and attempt to remove the tumor. While the patient was being examined by the house surgeon, on the day prior to the date fixed for operation, she suddenly fell back in bed, became cyanotic, and ceased to breathe. Artificial respiration was immediately begun, and so long as it was kept up the cyanosis was relieved, her pulse beating normally though rapidly. She was, however, completely unconscious. Artificial respiration was kept up in this manner for eight hours, all possible means of resuscitation were tried, but no natural respiration appeared to be possible, and although her heart continued to beat after respiration was suspended, it seemed impossible to prolong her life, and at the end of eight hours she died.

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[8] Some Points on the Surgery of the Brain, p. 232, Macmillan Co., 1907.
[9] Archiv f. Psychiatrie, xlv, 310, Berlin, "Zur Kasuistik der Gehirn Geschwülste."
[10] See Brain Surgery, p. 253.

No autopsy was permitted in this case, but recent investigations have shown that the cause of death in such cases is the pressure of the tumor above forcing cerebellar tissue downward into the foramen magnum and thus compressing the respiratory centre.[11] It seems reasonable to suppose that this occurred in this patient. The condition found in the case soon to be described (Case VI) warrants this supposition.

Bernhardt[12] called attention to the greater frequency of sudden death in cases of tumor of the cerebellum than in tumors elsewhere in the brain, his statistics showing the ratio as 24 per cent. to 7 per cent.; and both Oppenheim and Bruns confirm this observation. Horsley[13] recorded 3 cases of sudden death in his record of 95 cases of brain tumor. Tietze[14] reported a sudden death after lumbar puncture, and Cushing[15] has called particular attention to the risk of lumbar puncture in cases of cerebellar tumor, and has recorded two fatal cases and one case in which life was saved by prompt operation after respiration had ceased.

In the following case the diagnosis of a cerebellar tumor was comparatively easy, but the result of the operation was not favorable:

CASE V.—*Glioma of the cerebellum, invading the pons; operation; death.* L. B., aged seven years, was sent to me by Dr. Francis, of Montclair, on September 30, 1904. Her symptoms had gradually developed during two years prior to this time, following a blow upon the head on the left side in the parietal region, where there existed a marked thickening of the bone. Headache, vomiting, and optic neuritis had developed slowly, with a progressive diminution of her mental development, and after a year of these symptoms ataxia in her gait was noticed, together with an awkwardness of the arms, most marked upon the right side. The ataxia of gait increased steadily during the second year, so that when she was examined it was very difficult for her to walk, and in consequence of the inactivity of the right side, there was a marked atrophy of both arm and leg, considerable weakness in them, and a slight disturbance of sensation felt as a numbness.

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[11] For a photograph of this condition see Turner and Stewart, Text-book of Nervous Diseases, p. 236.

[12] Beiträge zur Diagnostik der Herngeschülste, Berlin, 1881.

[13] Brit. Med. Jour., August 23, 1906.

[14] Berlin. klin. Wochenschr., May 18, 1908.

[15] Interstate Med. Jour., September, 1909.

During the year prior to the date of examination she had had four attacks of stupor, each lasting several days. They were usually preceded by vomiting and attended by high temperature, and on each occasion the child's life was despaired of, as it was impossible to feed her, and the bladder and rectum were not under control. After each of these attacks, however, she gradually recovered consciousness, and seemed a little better after each attack than she had been before it.

When examined, she was found to have double choked disks and to be almost completely blind. She had exophthalmos of the right eyeball and paralysis of the right external rectus muscle. She had a flattening of the right side of the face, a loss of corneal reflex, slight anesthesia of the right side of the face, and some deafness in the right ear. She could not sit up or hold her head up, and when held up it tended to fall forward. She had a very marked ataxia of the right hand and of the right leg, some ataxia also in the left hand. No absolute paralysis in any muscle. No history of convulsions, of vertigo, of insomnia, of change of pulse. A course of mercury and iodide of potassium had been carried out with marked improvement for a few months, but was followed by a relapse.

The diagnosis in this case was a tumor in the right half of the cerebellum on the base, compressing the sixth, seventh, and eighth cranial nerves on the right side, and producing the ataxia of the right limbs due to injury of the cerebellum on the right side; and an operation was at once recommended. This operation was done by Dr. McCosh on November 15, 1904, at the Presbyterian Hospital. The occipital bone was exposed over the right side, but when the periosteum was stripped back venous hemorrhage occurred in an alarming condition from the bone, which appeared to be soft and porous, and which was controlled only by packing and pressure. This packing was removed on the second day, but the bleeding recurred, so that further opening of the skull was not deemed possible. At this time a tube of radium was inserted into the wound and left in for half an hour, and following this each day for five days the back of the head was exposed to the $x$-rays for ten minutes.

The child was then sent home, as an operation was thought to be impossible, but as the symptoms, which had at first been relieved, possibly by the bleeding, recurred, and as her condition was very serious, a second operation was undertaken on December 31.

The cerebellum was exposed, and on this occasion bleeding was not severe. Exploration with the finger and with a needle failed to expose the tumor, probably on account of lack of room, the exposure having been unilateral only. The wound was then enlarged upward, the tip of the occipital lobe was exposed, a needle was introduced into the posterior horn of the lateral ventricle, a large amount of fluid was evacuated from the ventricle, and horsehair drains were introduced through the aspirating needle and the needle was withdrawn, thus draining the lateral ventricle. During the following three weeks this drainage was kept up; at times as much as 20 ounces of cerebrospinal fluid drained into the wound. The evacuation of the ventricular effusion was attended by very marked relief, the child became bright and active mentally, the headache disappeared, and the congestion of the veins in the retina was considerably relieved, although her sight was not improved. At the end of that time, however, the child died.

The autopsy revealed the existence of a sarcoma, occupying the right lobe of the cerebellum, infiltrating this lobe, and reaching the base upon the right side, where it had pushed the medulla over toward the left side. A small projection of the tumor ran forward upon the pons Varolii and compressed the sixth, seventh, and eighth nerves at this point. The tumor also infiltrated the middle lobe of the cerebellum, so that it lay upon and compressed the floor of the fourth ventricle. It had no capsule, and it would have been very difficult to have removed it, had it been revealed at the operation, without removal of the hemisphere of the cerebellum. The ventricles were enormously distended, and contained 455 c.c. of serum.

In this case, even had a larger exposure of the cerebellum been made, it is evident that the operation would not have been successful, on account of the infiltrating character of the tumor. The futility of $x$-ray and of radium treatment in a glioma is demonstrated by the result of this case.

The last case to be recorded had, however, a much more favorable result.

CASE VI.—*Tumor of the cerebellar pontine angle successfully removed, with perfect recovery of the patient.* Female, aged forty years, was referred to me in October, 1908, by Dr. Synnott, of Montclair, N. J., and Dr. Broughton, of New York, with a history of gradually advancing brain tumor. She dated her symptoms from May, 1908, but there is reason to believe that they began much farther back in her history. Occasional sensations of vertigo had been felt at intervals since 1902. A severe attack of pain in the left suboccipital region lasting two weeks, which made riding in a carriage or jolting unbearable, had occurred in 1905, but had not recurred. While pregnant, in November, 1907, she suffered much from ringing in the left ear, and noises like the sound of a sea shell or the escape of steam; also from sudden faint feelings in the stomach. She miscarried in December, 1907, and then these symptoms ceased. From May, 1908, she had been suffering from headaches, especially severe in the morning on awakening, or on awakening from sleep if she slept in the daytime, headaches that were very markedly relieved by taking food, and that seemed to have had no definite location, but to have been felt all over the head, sometimes in front, sometimes at the back, and in the eyes. During the summer this headache was attended by a certain amount of deafness in the left ear and a slight flattening of the left side of the face, and with weakness of the orbicularis palpebrarum, so that in the act of winking it was noticed that she winked less forcibly with the left eye. During the summer considerable awkwardness of gait gradually developed, with a marked tendency to stagger in walking, and a feeling of falling, and by October this cerebellar staggering was very marked, so that she had to be supported in walking. During August she began to notice some disturbance of her eyesight, and it was this that led, in October, to her consulting Dr. Broughton, who discovered a double optic neuritis, a marked lateral nystagmus on motion to both sides, and a very marked prominence of both her eyeballs, with tendency of the eyeballs to diverge at rest. She had at that time no hemianesthesia and no paresis of the limbs, but the knee-jerks were markedly exaggerated.

The diagnosis was made of a tumor in the auditory region on the base, and the suggestion was made that she be treated with mercury and iodide of potassium, although there was no history of specific disease. Improvement in the symptoms began soon after this treatment was commenced, and for two months, November and December, she was practically free from her headache and her deafness was less marked, and her eyesight did not grow worse. In January, however, she began to suffer again from the same symptoms, gradually grew worse during February, and when I saw her on March 27, 1909, all her symptoms were more pronounced than at the first examination. Her headaches were very intense, so much so as to incapacitate her from all effort. They were worse at night and very much worse on awaking from sleep. She had vomited occasionally when the headache was very intense. They were still relieved by taking food, and she appeared to have an abnormal appetite, for she had gotten into the habit of taking food every two hours, which she seemed to digest well. But in spite of this, she had lost weight, she looked thin, and had the appearance of a person who was ill and in suffering. Her optic disks were much more swollen than they had been in October, her vision was reduced to $\frac{20}{70}$ in each eye; and there was a marked diminution of the visual field for colors. Vertigo was a constant symptom, but it did not appear to be a vertigo in any particular direction. The deafness in the left ear had increased so that a watch was no longer heard at the ear, and bone conduction was markedly diminished to the tuning-fork. Nystagmus was very evident on any motion of the eyes, but was distinctly worse when the eyes were turned to the left. Deviation of the eyes outward was still noticed, and a very marked exophthalmos, a little more marked in the left eye than in the right. The weakness of the left side of the face was pronounced, winking being imperfect, and a forcible closure of the left eye being impossible. Her knee-jerks were both exaggerated equally. She had begun to have some tingling and numbness in the left leg. In walking, she staggered more than she had before, and her staggering was now distinctly toward the right side. This was not due to any weakness of the right leg, which, on being tested, was found to be as strong as the other. She felt as if she were falling toward the right side when standing, and she swayed more toward the right side with her eyes closed.

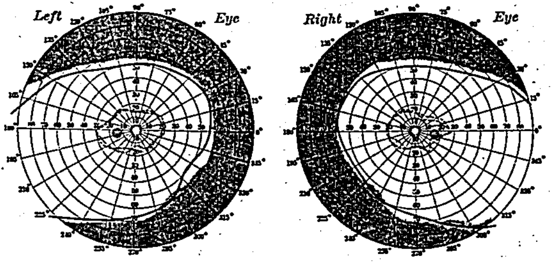

FIG. 2.—The visual fields prior to operation, showing contraction of the color fields, and interlacing of blue and red fields, with marked inversion of the fields. (Dr. Bordley.) (. . . . . red; —.—.—.— blue.)

The failure of the constitutional treatment to have any effect in relieving her permanently led me to advise an operation, and knowing the success which Dr. Harvey Cushing, of Johns Hopkins, Baltimore, had had in such cases, I suggested that she go to him for operation. After some delay this was agreed upon, and she went to Baltimore on May 14.

Examination in Baltimore at that time confirmed the existence of the symptoms here recorded, and, in addition, very careful perimetric measurements of the visual fields were made, which are here given. These showed a diminution of the visual fields of color, with an interlacing of the red and blue fields, as shown in the diagram, a condition which Drs. Bordley and Cushing have pointed out as a valuable symptom of brain tumor. The swelling of the optic disks was 5 D. At that time, before the operation, she was also suffering from numbness in the leg, arm, and face on the left side. She had a great deal of ringing in her left ear, associated with the deafness; she had marked double vision; she had a sensation of falling, especially toward the right side, and it was found that on lying on her back or on either side in bed, or on changing her position in bed, the sensation of vertigo was very markedly increased.

She could not lie at all on her left side. It was also discovered that in rapid motions of the hands some awkwardness was apparent in the left hand. This did not amount to any disability, as she could feed herself and fix her hair perfectly, but on simultaneous rapid motions of the fingers and wrist it was evident that the left hand presented a certain degree of incoördination. The staggering toward the right was particularly noticed. In obtaining her history Dr. Cushing elicited the fact that for a number of years she had been somewhat unsteady on her feet in certain movements. Thus, as far back as 1900 she had noticed in playing golf that she felt very unsteady when addressing the ball in sending it off, and that it had become practically impossible for her, in 1905–06 to play golf with her accustomed facility, because of the difficulty in maintaining her balance and hitting the ball accurately, so that in 1906 she had given up playing golf entirely.

It seems probable, therefore, that the symptoms had begun with a slight degree of imperfect balance eight years before the occurrence of the headache, which was considered the first symptom of the tumor, a fact which indicates that in all cases of brain tumor it is wise to ascertain whether little unusual manifestations of activity, sensation, speech, or conduct may not have preceded the active development of the symptoms by some years.

Another symptom elicited by Dr. Cushing was the occurrence occasionally during the two years prior to the development of the headache of peculiar attacks, known as vagal attacks—a sudden sensation of alarm and faintness without an actual faint, attended by palpitation of the heart and probably by a very rapid pulse—an indication of irritation of the vagus nerve or nucleus from pressure of the medulla. The patient had not thought it worth while to mention these symptoms, but when questioned, had a distinct remembrance of having had numerous such attacks for two years.

Dr. Cushing concurred in the diagnosis of a tumor in the cerebellar pontine angle, and on May 20 performed a successful operation.

The patient was laid upon the table, face downward, the body being supported by pads beneath the shoulders, which were adjusted before the anesthetic was given, and the head was supported by a special crutch adjusted to the forehead, not attached to the table, and after she was comfortably arranged the anesthetic was administered by a physician sitting beneath the table. A bow-shaped incision was made across the occiput and extended over on both sides to the ear, and a vertical incision in the median line was made downward from the middle of this bow-shaped cut. In this way two triangular flaps were made downward and outward, as indicated in Fig. 3. When the occipital bone in its entire surface had been exposed, small trephining openings were made on each side, and the opening was then enlarged by rongeur forceps until all of the central part of the occipital bone had been removed. The median ridge between these two openings was then rongeured away and the bone was taken away down to the foramen magnum. The posterior third of the bone forming the foramen magnum was also removed, it being evident that the brain within the dura was pressing downward into this foramen. When the occipital bone was thus entirely taken away and the foramen had been opened, it was evident that the intracranial pressure had abnormally increased, as the dura bulged markedly from the opening made, and when the dura was opened the compression of the cerebellar tissue beneath it was manifest not only by the bulging, but by the existence of a marked ridge upon the cerebellar tissue, showing the pressure that had been exerted along the edge of the foramen magnum, and the cerebellar tissue had evidently been forced downward into the foramen at least three-quarters of an inch below its upper level. This appearance of the cerebellum, having been forced downward into the spinal canal, confirms the statement made of the existence of such pressure, and of the possibility of such pressure producing sudden death by compression of the medulla. It is undoubtedly a fact that this patient would have died suddenly had this operation not been performed, and it is hardly conceivable that such a fatal

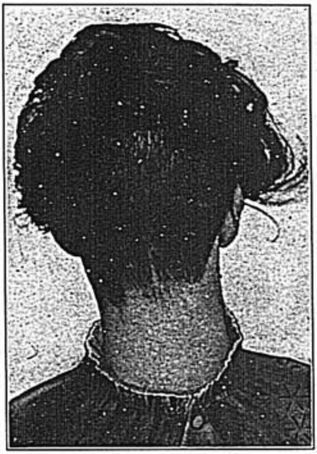

FIG. 3.—Showing field of operation eighteen days after it.

termination could have been postponed very long in consideration of the enormous amount of pressure evident from the cerebellum.

When the margin of the cerebellum was lifted and the pia was incised, a large amount of fluid escaped, and then the cerebellum fell back into its normal position.

By careful manipulation and raising the cerebellar hemisphere upon the left side and pushing the entire organ over to the right side, access, little by little, was obtained to the deeper structures. The difficulty experienced in previous operations (Cases I and II) of obtaining access to the base of the brain was obviated in this case by the possibility of displacing the cerebellum over to the right side, because of the removal of the right half of the occipital bone. Had but one-half of the occipital bone been removed, it would have been impossible to have exposed the deeper structures or to have reached the tumor. When the cerebellum was elevated sufficiently a white, hard mass was discovered by the finger and soon came into view, the wound being illuminated by a powerful electric lamp attached to the operator's head (Fig. 4). This tumor was evidently encapsulated, was not attached to the surrounding structures excepting by a small pedicle at its base; by careful manipulation with the finger and a spoon it was enucleated, its pedicle severed, and it was removed with a very little hemorrhage. Such hemorrhage as there was, was arrested by packing with cotton wet with

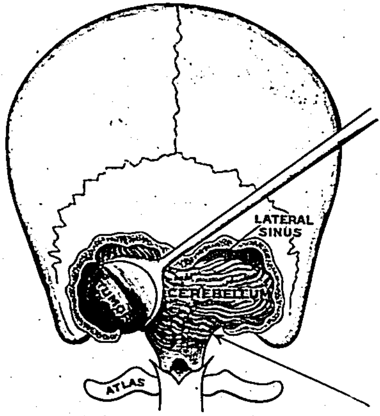

Fig. 4.—Sketch of operation by Dr. Harvey Cushing. The arrow points to the level of the foramen magnum showing the foraminal herniation of the cerebellum.

adrenalin solution. The removal of the tumor enabled the operator to have space enough to return the cerebellar tissue easily within the dura. The cavity left by removal of the tumor was filled by a sterile salt solution. There had been no laceration of the cerebellum attendant upon the operation. The dura was closed, the scalp sewed with silk sutures, and although the operation had occupied more than two hours, the patient had no perceptible shock, and on recovering from the anesthetic, was found to be very comfortable. She made a steady progress to recovery. Fig. 3 shows the condition of the scalp at the site of the wound eighteen days after operation.

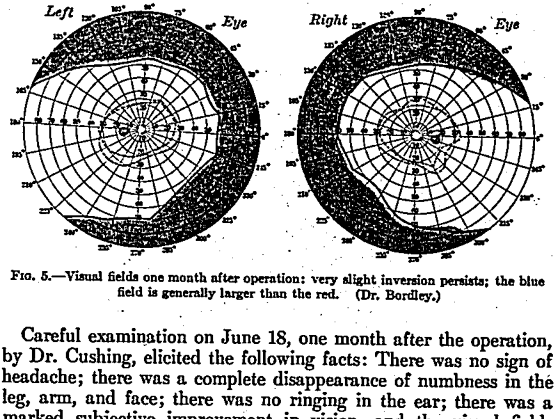

FIG. 5.—Visual fields one month after operation: very slight inversion persists; the blue field is generally larger than the red. (Dr. Bordley.)

Careful examination on June 18, one month after the operation, by Dr. Cushing, elicited the following facts: There was no sign of headache; there was a complete disappearance of numbness in the leg, arm, and face; there was no ringing in the ear; there was a marked subjective improvement in vision, and the visual fields showed a regaining of the normal contour, both for white and for color, a marked enlargement of the visual field for color being evident. The disks were reduced to 1.5 D. She was able to walk more steadily than for many months, but still felt a certain uncertainty in her gait, but had no tendency to stagger to one side. Her old discomforts associated with a change of position had disappeared. She was now able to lie on her back or on either side in bed. She had no longer any sensation of falling; the diminished acuity of hearing in the left ear to air conduction had practically gone, although there was a slight deafness still to bone conduction; the awkwardness in the left hand had disappeared. The only remaining evidence of the old lesion was the nystagmus of the eyes and the increased knee-jerks.

The appearance of the tumor is shown in Fig. 6, together with measurements in centimeters. The size of the tumor is 2.5 cm. in two of its diameters, and 2 cm. in the third diameter. It is a hard, white, encapsulated tumor, presenting the appearance of a fibroma, and was found to be, on microscopic examination, a pure endothelioma.

The examination of this patient, on February 5, 1910, shows a state of almost perfect health. She has no choked disks, the retinæ appear to be normal, her visual field is perfect for light and for color, and there is no congestion of the veins of the retina. She walks perfectly well, without any tendency to stagger, and has no vertigo. She has had no headaches during the summer. She has no anesthesia or weakness of any part of the face or body.

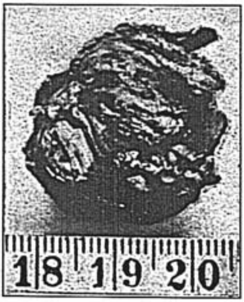

FIG. 6.—Endothelioma of acoustic nerve (centimeter measure)

She has nystagmus on lateral motion of both eyes, a slight deafness to the tuning-fork and to air conduction in the left ear, and exaggeration of both knee-jerks, but no ankle clonus, and she feels perfectly well. She goes about New York alone, her hair has grown naturally over the wound, and there is no tenderness of the scalp. The marked exophthalmos which was present has gradually subsided, so that there is no trace of it at present, and her winking is symmetrical on both sides.

The interest of this case lies, first, in the possibility of an accurate localization of the tumor, as shown by the analysis of the symptoms; second, in the possibility of successful removal when a sufficient field of operation is obtained by an extensive removal of bone; and third, in the fact that when such a tumor, lying upon the brain without destroying the brain tissue, is removed, a complete recovery of function in the brain tissue previously compressed is quite possible.

OPERATIONS FOR TUMORS OF THE CEREBELLUM AND ACOUSTIC NERVE. In the early days of cerebral surgery the results of cerebellar operations were so unfavorable as to make surgeons unwilling to undertake this operation, but as greater care and skill were developed, and the technique was improved, successful cases were more frequently recorded, so that, year by year, the percentage of recoveries increased. In 1905 Frazier was able to collect the records of 116 cases of cerebellar tumor in which an operation had been undertaken. In 52 cases the tumor had been found at the operation; in 34 cases it had been removed successfully, and in 17 cases recovery from the operation and from many of the symptoms which had been present prior to the operation had occurred. I have been able to collect from the literature between January 1, 1905, and January 1, 1910, 128 cases in which an operation had been undertaken, in which the tumor has been found and in which it has been removed (the tables of these cases are appended). I have not included in these tables cases in which an operation has been undertaken but in which no tumor was found, although there are nearly 50 such cases of failure recorded in the literature in the last five years. The analysis of these tables shows:

| | Cases. |
|---|---|
| Tumors of the cerebellum removed, with recovery of patient | 76 |
| Tumors of the cerebellum removed, with death of patient | 52 |

Constructing a table from the combination of statistics of Frazier and myself up to January 1, 1910:

| | Cases. |
|---|---|
| Total number of operations for cerebellar tumor | 294 |
| Tumors found and removed | 162 |
| Recovery of the patient from operation and from symptoms | 69 |

By the term recovery it is intended to imply not merely survival of the patient after the operation for a few days, but relief from the symptoms present in greater or less degree for a period exceeding three months. It is true that some of these patients remain with imperfect sight or hearing, and that some have remained somewhat ataxic in their gait, or with partial paralysis of some one of the cranial nerves. On the other hand, a number have been reported as completely recovered after several months, or even years, one case of Ballance having survived the operation already twelve years when the report was made.[16] In the case described in this article I see every reason to believe that the patient is permanently well, as she shows few, if any, symptoms at the end of ten months.

Such results certainly justify the operation, and make it evident that, as experience grows and technique is perfected, the many dangers of the operation will be overcome, the operation will be undertaken earlier, and the percentage of recoveries will steadily increase.

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[16] Ballance, Some Points on the Surgery of the Brain, p. 281.

*The Method of Operation.* A study of the various methods recommended by Horsley, Ballance, Borchardt, Krause, Biro, Frazier, and Cushing has convinced me of several important facts:

1. The necessity of a large exposure of the cerebellum by a bilateral operation, exposing and removing the entire occipital bone. Such an operation is long and difficult, the hemorrhage from the soft tissues and muscles of the neck is liable to be excessive, and in many instances an exposure of the occipital bone reveals foramina in that bone traversed by veins, giving the bone a cribiform appearance, which give rise to very severe hemorrhage. Thus, in a case of cerebellar tumor operated upon for me by Dr. McCosh, in 1900,[17] it was absolutely necessary to stop the operation on the exposure of the occipital bone, to plug the sinuses which were open with wax and with ivory points, and to give up any idea of further procedure, arresting the hemorrhage by bandages, the removal of which on the second day was followed by such a considerable degree of hemorrhage that any further attempt at removal of the bone was abandoned. The blood flowed through the foramina in the occipital bone in continuous stream, as if from a sinus, and the bone, which had been probably somewhat thinned by the pressure of the tumor within, bled freely wherever it was touched with an instrument. Others have found the same difficulty, but in cases of hemorrhage it is sometimes possible to arrest the hemorrhage by insertion of Horsley's wax into the bleeding foramina, or by plugging small openings with bone points or with wooden plugs.

2. A bilateral operation, removing the bone from both sides of the cerebellum, and then removing carefully the intermediate ridge of bone lying vertically between the two halves of the cerebellum over the occipital sinus, is necessary in order to give proper space for the displacement of the cerebellum to one side or the other during the operation, so that access may be had to the deeper parts in cases in which the tumor lies in the pontine angle. When only one side of the occipital bone is removed, the space opened is rarely more than two inches in diameter. Through this opening the cerebellum bulges greatly when there is a tumor within it or beneath it, and thus the cerebellar tissue stands in the way of any access to the deeper parts. In one case operated upon by Dr. McCosh,[18] under these circumstances, about one-half of the cerebellar hemisphere was sliced away and removed, much of it having become bruised and lacerated through bulging outward and by the necessary manipulations. This loss of cerebellum did not appear

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[17] This case is not included in those already cited—Case V in my table.

[18] This case is not included in the cases here cited. Case VII.

to have any ill effects subsequently upon the patient. Horsley has recorded a similar case,[19] in which a considerable part of the cerebellar hemisphere was destroyed in an operation without any ill effects. Hartley[20] also records a case in which a half of the cerebellar lobe was removed in an operation for the removal of a cerebellar tumor, where no tumor was found, but a decompression only was accomplished, in which case the patient recovered perfectly, and was well three years later, without any symptoms referable to a loss of one-half of the cerebellar lobe. While it appears, therefore, that a destruction of cerebellar tissue may be survived without any permanent ill effects, even to the extent of one-half of a cerebellar hemisphere, yet such a destruction of the cerebellum may be avoided by a bilateral exposure.

3. One of the dangers attendant upon this operation, and one which has led to sudden death during or immediately after the operation, is traction upon or pressure upon the vital centres in the medulla oblongata during the operation. If plenty of space is obtained for the displacement of the cerebellum to the side away from the tumor, by a large exposure, such pressure and traction may be avoided. It seems, therefore, incumbent upon the operators to expose the entire cerebellum before attempting to extract the tumor.

4. Inasmuch as this exposure is a difficult matter, involving considerable hemorrhage and taking a long time, it seems advisable that this operation should be completed and the removal of the tumor attempted at a second operation, to be done from five to ten days after the first. In this way shock, which is the second chief danger in these operations, may be avoided. Furthermore, the removal of the occipital bone relieves the intracranial pressure at once, and in some cases in which the tumor subsequently was not found, this decompression in itself has been sufficient to cause great improvement in the symptoms. Thus, I desire to put on record here the history of a case of a young man sent to us from Charleston, S. C., the son of a physician, who was operated upon by Dr. McCosh, in the Presbyterian Hospital, in 1902.

CASE VII.—*Probable cerebellar tumor; decompression; recovery.* This young man presented all the general symptoms of tumor—headache, vertigo, vomiting, and optic neuritis—together with marked cerebellar ataxia and tendency to stagger backward, but without any symptoms referable to the cranial nerves or to the tracts passing through the pons and medulla. The tumor was, therefore, thought to be in the middle lobe of the cerebellum and beneath the tentorium, and not near the base.

In this case both halves of the cerebellum were exposed by a free removal of the occipital bone, but no tumor was to be found after careful exploration with the finger and with an aspirating needle in all directions. The operation, which was followed by immediate surgical recovery, was succeeded by a general progressive improvement, the choked disk gradually subsiding, though the sight did not improve materially, as permanent damage had been done to the optic nerves, but his headache, vomiting, and vertigo were relieved, his ataxia disappeared, and he went home at the end of two months fairly well, and has been heard of at intervals since, having been apparently entirely relieved from his symptoms, excepting for a moderate degree of blindness. The last report was four years after the operation.

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[19] Brit. Med. Jour., August 23, 1906.

[20] Annals of Surgery, xlv, 518.

Similar cases have been recorded by Cushing[21] and by other operators, and in Frazier's statistics 13 per cent. of the patients were improved by the operation, even when the tumor was not removed. The relief of pressure, therefore, at the first operation, is likely to improve rather than to hurt the patient.

5. In the second operation, or the second stage of the operation, the first step is to prevent hemorrhage from the occipital sinuses, by tying them with an aneurism needle and double suture before the dura is divided. Then a transverse incision, curved upward, is to be carried from one side across to the other, allowing the dura to be reflected downward, so as to give a thorough exposure of the cerebellum. It is most important that in the removal of the occipital bone the posterior edge of the foramen magnum should also be removed. In a large number of the cases of cerebellar tumor a portion of the cerebellum is wedged down into the spinal canal. If the posterior portion of the foramen is removed, the cerebellum can easily be loosened and turned upward without undue traction. When the dura is divided the cerebellum may be lifted upon the spatula, and exploration of the cerebellar pontine angle may thus be made. In this procedure the cerebellum has to be pushed over to the opposite side, and anyone who has watched this operation will realize at once this procedure, which is essential to the discovery and removal of a deep tumor, is practically impossible unless both lobes of the cerebellum are exposed and plenty of free space for the dislocation of the cerebellar hemisphere toward the middle line is allowed for. In the case here recorded, which was operated upon by Dr. Cushing, unless this procedure had been feasible, it would have been practically impossible to get access to the deep tumor, which lay at least three inches below the surface of the dura.

6. A study of the records of cases operated upon and here cited has shown that in many cases laceration of the acoustic or facial nerve has occurred during the removal of the tumor, and more frequently still, laceration of deep-lying bloodvessels has been attended by

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[21] Surgery, Gynecology, and Obstetrics, 1906. This was a case first seen by me, in which I recommended the operation.

hemorrhage, not only difficult to control at the time, but subsequently leading to a fatal termination. Such hemorrhage can only be avoided by great care in the extraction of the tumor, by tying such vessels as are seen to pass into its space prior to its removal, and by a free access to the cavity after the tumor has been removed, so as to allow for tying any vessels that are still actively bleeding. If hemorrhage is entirely arrested at the completion of the operation, and no oozing occurs into the cavity left by the removal of the tumor, it is perfectly safe to close up the wound completely without drainage. This was done in the operation by Dr. Cushing, here described, with a consequent primary union of all the sutures in the scalp, with, practically, recovery from the operation on the twelfth day.

There appears to be no reason why the occipital bone should not be entirely removed from a patient. An osteoplastic flap is extremely inconvenient and practically impossible to make in this region of the skull, especially if the posterior portion of the foramen magnum is to be removed. The thickness of the muscle and fascia at the back of the neck is such that it gives adequate support to the brain, and the absence of the occipital bone consequently leads to no discomfort. In the patient whose history is here recorded, and who is now practically well, there has not been any pressure upon the scalp, there is no pulsation to be felt through the scalp, there is no weakness in the muscles moving the head, the hair has grown as thickly as ever, and in itself acts as a protector, and the patient suffers no inconvenience from the loss of her occipital bone.

THE PATHOLOGY OF TUMORS OF THE ACOUSTIC NERVE. The study of the nature of the tumors found and removed has an important bearing upon the prognosis in operations for brain tumor. A recent study of the pathology of acoustic tumors by F. Henschen[22] has shown that of 145 such tumors examined, 133 were solitary and 12 were multiple.

As regards the solitary tumors, it is interesting to note that a large majority were fibromas or fibrosarcomas, or cysts, encapsulated, non-adherent, and, from the standpoint of the pathologist, removable surgically. It is, therefore, evident that the danger of relapse after an operation for an acoustic tumor is far less than in cases of tumors elsewhere. Henschen calls attention to the fact that the acoustic nerve is the only cranial nerve frequently affected by a tumor. He brings this fact into relation with the observation that in embryonal growth the bone tissue which surrounds the acoustic nerve is formed later than that about the other cranial nerves, at their exit, and hence that embryonal connective tissue persists around this nerve later than elsewhere. He shows that tumors of this nerve usually (in 8 cases out of 9 examined by him) have a small pedicle entering the acoustic foramen or internal by a syringe. Thus, a small cylinder of brain tissue is obtained which may reveal tumor elements; or a cyst may be tapped which can readily be emptied by the aspiration.

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[22] Hygeia Festbund, 1909, No. 14.

Baisch[30] reports 2 cases of acoustic tumor in which puncture revealed the existence of a cyst. In the first case the subsequent operation showed it to be a part of a glioma, which was successfully removed, with the recovery of the patient. In the second case the evacuation of the cyst through aspiration was followed by such marked improvement that no operation was found necessary, and the patient was reported as recovered. In view of these facts, is it not incumbent upon us to urge this method of diagnosis in all brain tumors?

### Tumors of the Cerebellum Found and Successfully Removed, with Recovery of the Patients from the Operation.

1904. Stewart and Holmes, Brain, xxvii, 560. 11 cases.
1904. F. R. Fry, Jour. Nerv. and Ment. Dis., March. Tubercular.
1905. Borchardt, Arch. f. klin. Chir., lxxvii, 892. Cholesteatoma.
1905. Ziehen, Medizinische Klinik, p. 34. Glioma.
1906. Putnam and Waterman, Jour. Nerv. and Ment. Dis., May. Sarcoma, cyst.
1906. Horsley, Brit. Med. Jour., August 23. 9 cases.
1907. Homburger and Brodnitz, Mittl. aus der Grenzgeb. d. med. u. Chir., xix, 2. 2 cysts.
1907. Auerbach and Grossman, ibid., xviii, 1. Glioma.
1907. Schultze and Schede, ibid., xvii, 617. Glioma.
1907. Bruce, Annals of Surgery, xlv, 550. Cyst.
1907. Rubritius, Beitr. z. klin. Chir., lxiii, 447. Cyst.
1907. Oppenheim and Borchardt, Berl. klin. Wochen., xliv, 875. Fibroma, sarcoma.
1907. Ziehen, Archiv f. Psychiatr., xlv, 768. Glioma.
1907. Borchardt, Archiv f. klin. Chir., lxxxi, 181. 3 cases.
1907. Poppert, Deut. med. Wochenschr., p. 613. Fibroma.
1907. Ballance, Some Points on the Surgery of the Brain. Tubercle.
1908. Weisenberg, Jour. Amer. Med. Assoc., No. 16. Fibroma.
1908. Baisch and Narath, Beitr. z. klin. Chir., lx, 482. 2 cysts.
1908. Bramann, Berl. klin. Wochenschr., August 10. 9 cases (3 relapses).
1908. Tietze, ibid., Cyst.
1908. Adler, ibid., Cyst.
1908. Foerster, Berl. klin. Wochenschr., April 6. Cyst.
1908. Willy Meyer, Jour. Nerv. and Ment. Dis., September, p. 584. Fibrosarcoma.
1909. Jones, Boston Med. and Surg. Jour., August 26.
1909. Kuttner, Allgem. med. Central Zeitungen, lxxiii, 198. Glioma.
1909. Ziehen, Medizinische Klinik, No. 1. Cyst.
1909. Krause, Hirn Chirurgie, Berlin, 1909. Cyst.
1909. Cushing, Interstate Med. Jour., St. Louis, September. 11 cases.
1909. Grinker, Jour. Nerv. and Ment. Dis., May. Fibroma.
1909. Leischner, Arch. f. klin. Chir., lxxxix, 542. Sarcoma.
1909. Borchardt, Oppenheim, Centralbl. f. Chir., April. 2 cysts.
1909. Starr and Cushing, Present article. Endothelioma.

### Tumors of the Cerebellum Operated for and Removed, with Death of the Patients.

1904. Stewart and Holmes, Brain, xxvii, 525. 6 cases.
1906. Horsley, Brit. Med. Jour., August 23. 1 case.
1906. Funkenstein, Mittl. aus der Grenzgeb. der med. u. Chir., xiv, 157. Neuroma.
1906. Rubritius, Beitr. z. klin. Chir., lxiii, 447. Neurofibroma.

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[30] Beit. zur klin. Chir., 1908, lx, 482.

1906. Bruns, Neurol. Centralbl., p. 971. 2 cases.
1906. Borchardt, Arch. f. klin. Chir., Band lxxxi. 3 cases.
1906. Poppert, Deut. med. Woch., p. 613. 3 cases.
1906. Auerbach, Deut. med. Woch., p. 614. Sarcoma.
1906. Ballance, Some Points on the Surgery of the Brain (Macmillan). 2 cases.
1908. Martens, Berl. klin. Wochensch., August 10., No. 32. Glioma.
1908. Bramann, ibid. 1 case.
1908. Tietze, ibid. Tubercle.
1908. Kredel, Centralbl. f. Chir., April, 2 cases.
1908. Siemmerling, Berl. klin. Woch., p. 701. Sarcoma, fibroma.
1908. Henschen and Dahleren, Hygiea, No. 44. Cyst.
1908. Becker, Deut. Arch. klin. Med., Band lxxxix.
1908. Ebsberg, Jour. Nerv. and Ment. Dis., September, p. 586. 1 case.
1908. Weisenberg, Jour. Amer. Med. Assoc., January. 1 case.
1908. Hunt, J. R., Jour. Nerv. and Ment. Dis., September. 4 cases.
1909. Flatau, Neurolog. Centralbl., p. 399. 1 case.
1909. Boettiger, Neurolog. Centralbl., p. 167. Cyst.
1909. Krause, Hirn Chirurgie, Berlin, 1909, p. 141. 3 cases.
1909. Cushing, Interstate Med. Jour., September, xvi, 607. 3 cases.
1909. Lomois and Durand, Ann. des mal dé l'Oreille, March. Glioma.
1909. Biggs, Lancet, July 3. Fibroma.
1909. Grinker, Jour. Nerv. and Ment. Dis., May, p. 304. 1 case.
1909. Leischner, Arch f. klin.. Chir., lxxxix, 542. Cystoglioma, Neurofibroma.

## TABLE OF PERSONAL CASES.

| No. | Name. | Age. | Situation. | Operation. | Result. | Surgeon. | Autopsy. |
|---|---|---|---|---|---|---|---|
| 1 | M. | 30 | L. hemisphere base and left pons | Tumor not found | Recovery from operation; death 7 days later | McBurney | Glioma. |
| 2 | W. | 10 | Cerebellar pontine angle | Tumor found and removed | Recovery from operation; death 14 days later | McBurney | Cystoglioma. |
| 3 | B. | 7 | Cerebellum and pons | Tumor not found | Died three weeks later | McCosh | Sarcoma. |
| 4 | G. | 39 | Cerebellum and pons | Tumor not found | Death 7 days after | Brewer | No autopsy. |
| 5 | C. | 6 | Cerebellum and pons | Bone only exposed; hemorrhage | Unknown; child taken home | McCosh | |
| 6 | G. K. | 8 | Cerebellum | Cystoglioma found and partly removed | Death 6 days later | McCosh | Glioma and cysts within it. |
| 7 | A. T. | 11 | Cerebellum | Removal of part of occip. bone; excessive hemorrhage | Improved; discharged one month later | McCosh | |
| 8 | L. H. | 13 | Cerebellum | Decompression; tumor not found | Improved for two years | Cushing | |
| 9 | W. F. | 17 | Cerebellum | No tumor found, decompression only | Death | Hartley | Sarcoma of optic thal. |
| 10 | G. H. | 18 | Cerebellum | No tumor found; bilateral decompression and some cerebellar tissue removed | Well | McCosh | |
| 11 | F. A. | 32 | Cerebellar pontine angle | Removal | Recovery | Cushing | |
| 12 | A. D. | 20 | Cerebellum | None | Death suddenly day before operation | McCosh | Glioma with cyst in cerebellum. |
| 13 | K. | 17 | Cerebellar pontine angle | None | Sudden death prior to operation | McCosh | No autopsy. |

I have appended to this article the record of 13 personal cases of tumors of the cerebellum, in 11 of which an operation was performed, and in 2 of which sudden death occurred just prior to an operation which had been determined upon. Three of these cases (I, II, and III) were included in Frazier's statistics. Case VIII is included in the statistics of Cushing. The other cases have not been published.

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# THE TREATMENT OF HEMORRHAGE OF THE SPLEEN.

By John G. Sheldon, M.D.,
of Kansas City, Missouri.

The treatment of traumatic hemorrhage of the spleen by the methods ordinarily advised and practised is, as a rule, unsatisfactory.

Splenectomy. Splenectomy, which of course stops the bleeding, is, to say the least, an undesirable operation. It is associated with considerable shock, deprives the patient of an organ that may be of considerable physiological importance, and it is not always easily or quickly accomplished. The mortality following splenectomy for hemorrhage is approximately 50 per cent. if the operation is done soon after the injury occurs. Berger[1] collected eighty cases of wounds of the spleen treated by splenectomy not later than nine hours following the injury; in thirty-five of these death occurred within twenty-four hours.

Splenorrhaphy. The suturing of splenic wounds, recommended by Lamarchia, Madelung, and others, is an unsafe procedure. Its field of application is limited, and it cannot be relied upon to control hemorrhage in any case.

Senn's Method. Senn[2] recommends that in selected cases of splenic wounds the margins of the wound should be crushed and sutured. This method succeeded in stopping the hemorrhage in seven dogs in which incised marginal splenic wounds had been made. The application of Senn's method is limited, and on account of the thinness of the dog's spleen as compared with the human organ, it is probable that the experimental work magnifies the practical utility of Senn's procedure.

Jonnesco's Method. Ligation of the splenic vessels to control splenic hemorrhage, recommended by Jonnesco, stops the bleeding, but is followed by necrosis of the spleen, and in dogs results in death. Pirone suggested that after the splenic vessels had been tied, the great omentum might be utilized to supply nourishment to the organ, and thereby prevent necrosis. This I have tried on three

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[1] Arch. f. Chir., Band xxviii, Heft 3.

[2] Int. Cong. of Med., Madrid, November 21, 1903.